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Designing an IT-Based System for Optimizing Lung Cancer Management

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Emergent Research Forum (ERF)

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Abstract

Digital health offers lung cancer patients to improve their health status while allowing patients, providers, and administrators to coordinate data and care at individual and community levels. While technology improvements provide lung cancer patients and healthcare providers with a valuable new tool for disease management, these are yet to be widely accepted. In particular, we aim to: (1) develop a Machine Learning (ML)-based framework for data collection from active online lung cancer forums and other parameters for patients, providers and their organizations, (2) build an AI-based model to develop a cancer ontology for exploring different factors and patients' emotions associated to lung cancer management, (3) Design a mHealth app to set up a support system in terms of providing patients with information and social support, and ML models-based treatment recommendation system. The IT-based support system will provide the best and most specific treatment plan and recommendation system for lung cancer management.

Keywords

Lung cancer, online cancer forums, mHealth, decision support system.

Introduction

Lung cancer is the deadliest of the main types of cancer among men and women in the United States (U.S). According to the most recent data from the National Cancer Institute, 235,760 lung cancer cases were diagnosed in 2021, 12.4% of all new cancer cases with 131,880 associated deaths in 2021, accounting for 25% of all cancer deaths in the U.S ((NIH-NCI) 2021). The recent statistics from the American Cancer Society reveal that approximately 236,740 new lung cancer cases are expected in 2022, with approximately 130,180 new associated deaths (Society 2022). Each year, lung cancer claims the lives of an estimated greater number of people than all three of these other cancer types, such as colon, breast, and prostate cancers. The majority agree that mobile health (mHealth, which refers to the use of portable devices for medical purposes) shows a significant impact on improving cancer patients' healthcare and overall quality of life. The potential market for mHealth is huge, and it is expected to keep expanding as internet availability grows throughout the world, with over 70% of the public in the U.S owning smartphones (Tarricone et al. 2019). Designing patient-centered digital care for the decision support process is essential for operation management and strengthening physician-patient interactions.

Individuals diagnosed with cancer are increasingly turning to online cancer forums (OCF), searching for advice and support. These forums serve as a support group for those seeking and receiving assistance related to OCF users. Some of them may be familiar with the support expressed (through personal experience) (Andy and Andy 2021). Greater knowledge of the online cancer narrative is critical for a more nuanced conceptualization of the function of social media platforms in facilitating health-related support (Cabling et al. 2018). Furthermore, the efficient delivery of high-quality healthcare is a critical societal

goal, particularly in increasingly restricted available financial resources (Balakrishnan et al. 2021). When it comes to the oncology domain, the process of providing care is heavily influenced by the data-driven (Crook and Love 2017). The exchange of data between patients and healthcare providers can improve patient symptom management and lower the cost of care (Cillessen et al. 2020).

Artificial intelligence (AI) affects various facets of our lives by altering how we examine data and enhancing decision-making through problem-solving and learning. Oncological healthcare is increasingly digitized, with data gathered from sources other than hospitals and providers, such as platforms, medical equipment, life sciences, and medical research (Galetsi et al. 2020). Oncology patients require high-quality care, which requires a real response and advanced analytics, AI, and machine learning (ML) tools (Wang et al. 2018). Machine intelligence algorithms successfully applied to medical data can revolutionize many aspects of medical practice by enhancing diagnosis accuracy, diagnosing the source and progression of the disease, as well as creating viable treatments for cancer diseases. Even though technology improvements provide cancer patients and providers a valuable new tool for the decision support system, these are yet to be widely accepted. There are three major gaps observed in the earlier process: (1) a lack of publicly available annotated datasets that affect the generalizability of traditional ML tools; (2) absence of latest ML tools that implicitly analyze internet-oriented users' conversation based on the cancer ontology and other clinical parameters; and (3) lack of availability of an information technology (IT)-based clinical decision support system for lung cancer management.

Motivation

This work aims to develop an IT-based clinical decision support framework (mHealth app) that uncovers AI and Big Data analytics capabilities for optimizing lung cancer treatment. For healthcare providers, the proposed framework will reveal the potential benefits of these technologies in terms of enhancing the quality of care and for patients lowering the search cost in deciding the best healthcare provider. This work suggests the following connected aims:

Aim 1. Develop a ML-based framework to collect lung cancer-related data.

The proposed framework aligns multiple measurements for lung cancer disease management. The relevant dataset is collected from 1) active OCF *lungcancer.net*, *lungevity.org*, and *reddit.com* in the form of lung cancer-related topics and news, as well as stories of survival, loss, and anything else related to the disease, 2) parameters about the treatment effectiveness of medications and techniques will be extracted from online platforms such as *reference.medscape.com* and *webmd.com*, whereas *electronic health records* will be used for prognosis and diagnosis. These records generate massive amounts of data daily, providing a rich source of information that will be used for designing the preventative, prognosis, diagnostic, and treatment aspects of the mHealth app. Finally, 3) other parameters regarding healthcare providers will be collected from published reports and online databases. Before formal analysis, this study adopted the intended data pre-processing strategy for the model development as in (Shah et al. 2019).

Aim 2: For social network analytics, build an AI-based Sentic computing model to develop lung cancer ontology with different terminology for exploring different factors and patients' emotions associated with cancer treatment.

Mining online conversations and health-related parameters will assist healthcare providers in optimizing their services and enhancing patient care. We will use a variety of data mining techniques to look through user posts regarding informational and emotional support from community members and extract topics and emotions from these posts. An AI-oriented Sentic computing framework will be designed to figure out what people are talking about in their posts. Sentic computing is a hybrid method to affective computing and opinion analysis that employs AI and semantic web methods across multiple disciplines (Cambria 2016). The development of cancer ontology with new terminology in the combination of SenticNet under the guidance of Sentic computing will result in creating a sentiment model that connects polarity values to notions of common-sense knowledge. The semantic parser in the model will divide the text into clauses and hence break them into bags of concepts that will be later fed to a vector space model to find connections between multi-word phrases. Spectral association and concept frequency-inverse opinion frequency (CF-IOF) as a component of truncated singular value decomposition (TSVD) will be used to order popular and domain-related concepts into latent factors. After identifying topics, two domain specialists will label these extracted topics keeping in view the keywords associated with each topic.

Labeled topics will then be clustered under different healthcare factors related to patients' treatment experience in the oncological domain. After the compilation of significant factors associated with patients' treatment experience, the Hourglass of Emotions (HOE) model (which includes cancer ontology-based SenticNet and most prominent machine intelligence algorithms) will be used to determine the sentiment polarity of the classified factors. Finally, to evaluate the model performance, we will compute the system accuracy and precision to determine classification performance and analyze and visualize our results.

Aim 3: Developing a mHealth app to set up a support system to provide patients with information and social support, treatment recommendations, and improving care quality.

Based on the web analytics, this study presents mHealth-based decision support system that incorporates real health interventions for the ML model-based treatment recommendation system to identify high-quality healthcare providers. As a result of the growing interest in mHealth analytics, it will be beneficial for healthcare providers to improve their service quality and enhance patient treatment choice.

Innovations

This work presents a powerful AI-based decision support tool in the digital healthcare environment (mobile devices) by combining and analyzing various aspects of health-related information. The proposed approach uses Big Data to provide a ML-based recommendation system for lung cancer management, thus improving clinical services and minimizing patient search costs. The following are some of the major contributions to the existing body of knowledge that make this work novel:

Innovation 1: Developing a rigorous ML tool to scrape patient, medication and techniques, prognosis, diagnosis, and physician-related data from different OCF, published reports, and online databases. Since only 42% of healthcare firms surveyed use rigorous analytics to assist their decision-making, and only 16% have extensive expertise in using analytics across a broad range of tasks (Sharma et al. 2014). This indicates that healthcare professionals have a hazy understanding of how Big Data may add value to their organizations. Hence, there is a pressing need to comprehend the strategic implications of Big Data in the oncological domain. Our approach will reap these benefits of transforming oncological healthcare into digital care, where patients will receive information specific to lung cancer and treatment procedures.

Innovation 2: Programming a powerful social network analytics approach based on AI that implicitly analyzes patients with lung cancer opinions posted on publicly available digital platforms to report a forthcoming intervention in the form of different factors and emotions related to cancer care. This study will analyze Big social media Data using Python 3.8 (Python Software Foundation) from five perspectives: public health awareness, stakeholder interactions, hospital administration, treatment of specific medical diseases, and technology in service delivery. The proposed IT approach has the potential to improve patient care, strengthen the physician-patient connection, and reduce search costs and hospital lawsuits.

Innovation 3: Developing a patient-oriented mHealth app based on the factors identified in the earlier step to help patients with lung cancer in their clinical decision-making process. This project will design, develop, and test mHealth app, including several indicators for the clinical decision support system. To help build an early planning mechanism, the study's results will give a foundation for planning treatments and interventions as well as financial and resource requirements for lung cancer patients.

The reference mHealth apps evaluated for this investigation were found in the "Health and Fitness" section of the British Apple App Store (iOS). We also explored several other apps from past work in the digital health domain and found them could be appropriate for the current project. An overall framework of the study is shown in Figure 1. The following criteria will be used to determine which features could be appropriate for designing a mHealth app (refer to Figure 2) for lung cancer management:

- Typicality: This app should be representative of many prominent available mHealth apps, even though it needs to differ from the others in terms of content, format, and features.
- Suitability: The apps had to be suitable for those who had cancer treatment and, as a result, had to be flexible enough to accommodate various levels of fitness. A physician specializing in oncology will evaluate the app's features to see if they are appropriate for breast, prostate, and cancer survivors.
- Stability: The app must be available at least 6 months after the study completion.
- Availability: The app must be compatible with both iOS and Android systems.

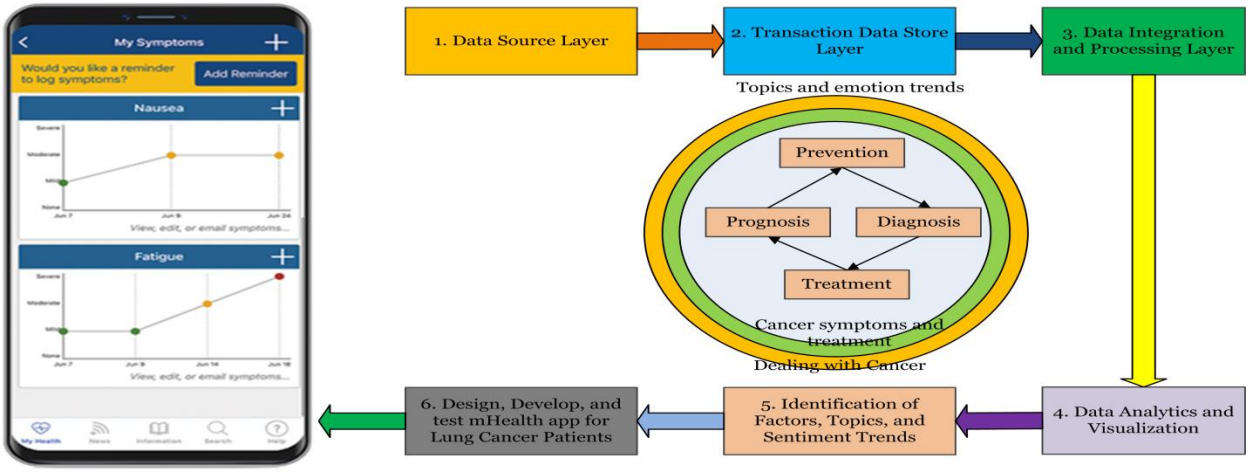

Figure 1. The Proposed mHealth Framework for Patients with Lung Cancer

The main interface of mHealth app consists of eight different tabs (refer to Figure 2) including: **1) Treatment** (different ***stages*** of lung cancer, ***treatment*** plans to cure patients, ***side effects*** of different treatment for cancer patients, ***traditional medicine*** database used to cure different kind of cancer diseases, ***meta and relapse*** to coping with different kind of stress and depression, ***gene*** transfer procedures a novel therapy method that involves inserting new genes into a malignant cell or surrounding tissue in order to cause cell death or delay cancer progression, ***clinical trials*** to avoid, diagnose and cure cancer, **2) Physical activity** (involve exercise options for cancer therapy and the ***rehabilitation*** tab is designed to assist patients in regaining, maintaining, or improving abilities that they require on a daily basis, **3)** Patient **emotions** (tabs include patients who seek ***emotional support***, ***mental support***, and ***music therapy***), **4) Diet advisory** (guidelines regarding certain ***diets***, diet ***recipes***, and ***food stuff*** as value that brings to the cancer patients), **5) Health records** for each user (***diet*** record, patient ***sentiment***, patient ***physical activities***, patient disease ***symptoms***, and patient ***social circles*** like peers, care givers, friends, etc.…), **6) Social resources** (International Cancer organizations and other resources, ***Cancer therapy centers***, uses of ***technology***-based resources and programs, ***technology orientation*** toward the implementation of technology-based systems, and ***economic support*** that patient receives), **7) Experience sharing** (***Information sharing*** regarding the different stages of cancers, ***online peers*** discussion, and cancer ***support groups***), and **8) Expert consultation** (***virtual consultation*** with healthcare provider, ***instant messaging*** like chat bots, etc.., and ***FAQ***/frequently asked questions). The mHealth app will be monitored regularly to update health-related information, providers' record, and motivate users to participate actively online. For this purpose, this study will develop an engagement index and user activity ratio to monitor participant interaction and participation on mHealth platform. The proposed mHealth app will be a unique recommendation system for lung cancer disease management that includes multiple interfaces connected to multiple databases.

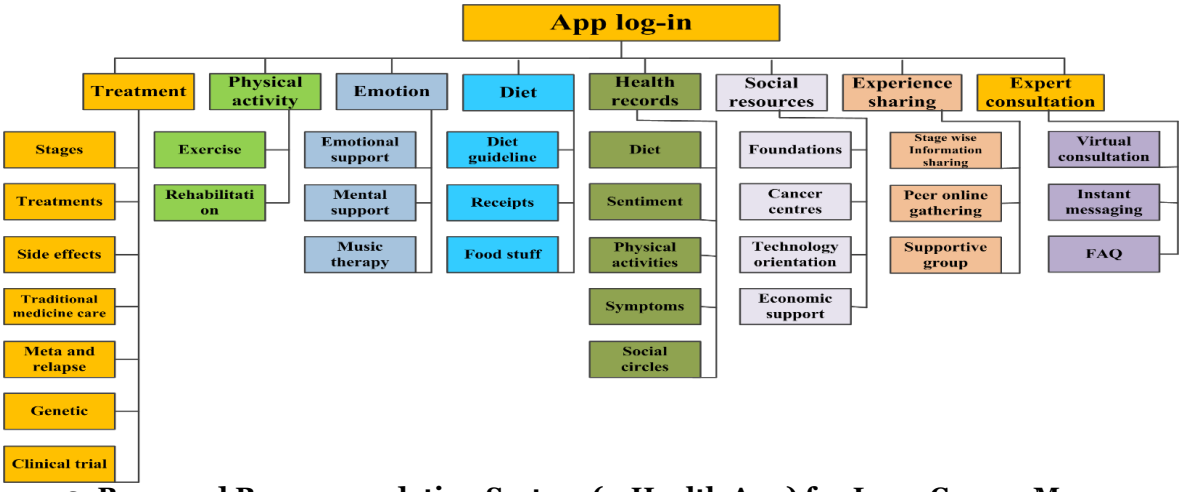

Figure 2. Proposed Recommendation System (mHealth App) for Lung Cancer Management

Conclusion

Scientific investigations regarding disease management in the digital oncology domain are still in the early stages. Outcomes of the study would demonstrate that combining AI with Big Data analytics plays a pivotal role in mHealth and improves health outcomes of patients with lung cancer. The advantages of employing IT (mHealth) are driving healthcare system transformation, and more important changes and benefits will emerge in the future with the following expected outcomes.

(1) For patients using AI-based mHealth technology, this project will help in improving provider-patient communication and relationship, increase patient satisfaction, expand informational support to patients, families and caregivers, better and persistent self-assessment, and reduce search costs, **(2)** In addition, the developed mHealth technology will provide patients, families, and caregivers with social and emotional support and improve mental health, such as reducing anxiety, social isolation, depression, social class, and neuroticism, **(3)** Our AI-based mHealth technology supports medication adherence, minimizes clinical errors, saves time through emergencies, improves the quality of care, scientific assessment, and strengthens clinical decisions in real-time for healthcare providers in the oncological domain, **(4)** At the industry level, this work will better understand medical data scientists to analyze the users' conversations in OCF and other healthcare parameters accurately and help them in designing ML-based treatment recommendation system, **(5)** This work will assist lung cancer patients in making better insurance decisions and provide a customized cost estimate of annual health care costs.

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